

Mikko Paananen

**ON INNOVATIVE SEARCH: THE USE OF INTERNAL
AND EXTERNAL SOURCES OF INNOVATION AMONG
FINNISH INNOVATORS**

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ABSTRACT

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This dissertation explores the use of internal and external sources of knowledge in modern innovation processes. It builds on a framework that combines theories such as a behavioural theory of the firm, the evolutionary theory of economic change, and modern approaches to strategic management. It follows the recent increase in innovation research focusing on the firm-level examination of innovative activities instead of traditional industry-level determinants. The innovation process is seen as a problem- and slack- driven search process, which can take several directions in terms of organizational boundaries in the pursuit of new knowledge and other resources. It thus draws on recent models of technological change, according to which firms nowadays should build their innovative activities on both internal and external sources of innovation rather than relying solely on internal resources. Four different research questions are addressed, all of which are empirically investigated via a rich dataset covering Finnish innovators collected by Statistics Finland. Firstly, the study examines how the nature of problems shapes the direction of any search for new knowledge. In general it demonstrates that the nature of the problem does affect the direction of the search, although under resource constraints firms tend to use external rather than internal sources of knowledge. At the same time, it shows that those firms that are constrained in terms of finance seem to search both internally and externally.

Secondly, the dissertation investigates the relationships between different kinds of internal and external sources of knowledge in an attempt to find out where firms should direct their search in order to exploit the potential of a distributed innovation process. The concept of complementarities is applied in this context. The third research question concerns how the use of external knowledge sources – openness to external knowledge – influences the financial performance of firms. Given the many advantages of openness presented in the current literature, the focus is on how it shapes profitability. The results reveal a curvilinear relationship between profitability and openness (taking an inverted U-shape), the implication being that it pays to be open up to a certain point, but being too open to external sources may be detrimental to financial performance. Finally, the dissertation addresses some challenges in CIS-based innovation research that have received relatively little attention in prior studies. The general aim is to underline the fact that comprehensive understanding of the complex process of technological change requires the constant development of methodological approaches (in terms of data and measures, for example). All the empirical analyses included in the dissertation are based on the Finnish CIS (Finnish Innovation Survey 1998-2000).

Keywords: Innovation, Innovative search, Search, Knowledge, Problems, Slack, Dynamic capabilities, Competitive advantage

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II Paananen, M., (2009). Exploring the relationships between knowledge sources in the innovation process: evidence from Finnish innovators. *Technology Analysis & Strategic Management*, 21, 6, 711-725.

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IV Paananen, M., Kleinknecht, A., (2010). Analysing innovative output in a CIS database: Factoring in some nasty details. *Economia e politica industrial - Journal of Industrial and Business Economics*, 37, 1 13-31.

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I Sole author.

II Sole author.

III Joint author. Made the research plan, ran the econometric analyses, wrote part of the paper.

IV Joint author. Made the research plan, ran the econometric analyses, wrote part of the paper.

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1 Introduction

1.1 The purpose of the study

Research has shown that innovations¹ drive firm-level economic growth, profitability and survival (e.g., Geroski et al., 1993; Cefis & Marsili, 2005). It is therefore increasingly important to understand what makes firms innovate and why some are more innovative than others. With a view to finding out, researchers first identified some industry-level determinants such as demand, technological opportunities, and appropriability conditions (Cohen, 1995; Klevorick et al, 1995; Pavitt, 1984). It was noted that except that while technological change tends to evolve in waves driven by technological paradigms² (Dosi, 1982; 1988; Teece, 2008), the evolution of technological progress along the specific lines within the such paradigms often takes place through technological trajectories³ that are usually associated with research and development activities (Dosi, 1982). In general, a central distinction between the two concepts above is that while the paradigms are mainly related to radical and discontinuous innovations, the trajectories are associated with incremental and continuous innovation within the paradigms (Dosi, 1982).

¹ Following OECD (2005), innovation can be defined "... implementation of a new or significantly improved product (good or service), or process, a new marketing method, or new organizational method in business practices, workplace or external relations" (OECD, 2005, p. 46). A new or improved product can be considered implemented when it is introduced on the market. In turn, new processes, marketing methods or organisational methods are implemented when they are brought into actual use in the firm's operations (OECD, 2005, p. 47). Importantly, innovation should be seen different from invention.

² Technological paradigm can be defined as " 'model' and a 'pattern' of solution of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies" (Dosi, 1982). Hence, technological paradigms are composed by some sort of model of the technology at stake (e.g. a combustion engine) and trajectories by the specific technological problems posed by such model (e.g. improvements in horsepower, cruise speed, etc.).

³ Dosi (1982) defined the technological trajectory as a "...pattern of "normal" problem-solving activity (i.e. of "progress") on the ground of a technological paradigm". It can thus be seen as a technological progress defined by the paradigm. As an example, Dosi (1988) highlights a technological progress of aircraft industry where evolution of two separate trajectories can be identified: military and civilian aviation.

Although there is empirical evidence indicating that external determinants mentioned above do drive firm-level technological change, it has since turned out that there are important sources of innovation inside the firm as well (Teece, 1986; von Hippel, 1988; Cohen & Levinthal, 1990). As a result, the firm-level strategy oriented innovation research has been significantly increased in the past few decades. Interestingly, a similar increase, when explaining the sources of competitive advantage, has been seen in research on strategic management (Porter, 1979; 1980; Wernerfelt, 1984; Barney, 1991; Teece et al., 1997). These two previously separate research streams (i.e. innovation and strategic management) are very much intertwined nowadays. Modern models of strategic management highlight the role of innovative activities as a central source of competitive advantage (Teece, 2000, part 1), thus the literature provides a fruitful platform on which to examine innovation in contexts characterized by competition.

These models have evolved over the years, enhancing understanding of how modern firms compete. The recent extension of the resource-based view of the firm (RBV) (Wernerfelt, 1984; Barney, 1986, 1991) to incorporate the dynamic capability view (DCV) (Teece et al., 1997; Teece, 2007; Barreto, 2010) has revealed how firms reconfigure their resources through dynamic capabilities in order to cope with rapidly changing business environments (Helfat et al., 2007). According to the DCV, the ability of firms to generate dynamic capabilities primarily arises from their capacity to innovate (e.g., to develop new products or business models) (Teece et al., 1997; Teece, 2007; Teece, 2010). Such capabilities do help firms not only to adapt to constant changes through innovation, but also to sense potential new innovation opportunities. Most importantly, the DCV posits that only firms that are able to overcome the challenges of dynamic change through the development of innovative

products, processes, and organizational solutions, or even to determine the direction of change in the marketplace through such innovations, are able to compete in global markets.

Given the key role of innovation, it is crucial for firms to understand the detailed mechanisms of the process, and how they should be managed in order to best promote and sustain competitive advantage. The theoretical roots of such mechanisms can be traced back to a behavioural theory of the firm (Cyert & March, 1963; see Pierce et al., 2002) and the evolutionary theory of economic change (Nelson & Winter, 1982), but also to some original ideas put forward by Edith Penrose (1959, see also Pitelis & Teece, 2009). All the authors conceptualize the innovation process, at least to some extent, as one of innovative search, as does this dissertation.

Innovative search is further defined here as a specific type of dynamic capability in modern strategic-management terms (for a parallel interpretation of new product development, see Eisenhardt & Martin, 2000; see also Helfat et al., 2007 and Teece, 2010). Given that the ability to innovate is such an essential capability for firms operating in a competitive environment, this dissertation makes a modest attempt to contribute to the current literature in this theoretical context through the empirical examination of some very specific areas of innovative search.

1.2 The research questions

The main research question (MRQ) of this dissertation is:

- **MRQ:** *How do modern firms manage their innovative search in terms of dealing with multiple internal and external sources of knowledge in a constantly changing business environment?*

The MRQ is broken down into the following four sub-questions (SQs) that explore specific themes related to innovative search behaviour of firms:

- **SQ1:** *How does the nature of the problems faced by firms shape the direction of their search for different sources of knowledge?*
- **SQ2:** *Where can firms find the knowledge they need in order to engage in innovative activities? What are the sources of new knowledge, and what is the role of complementarities in this process?*
- **SQ3:** *How do external search strategies shape firms' financial performance in open innovation context?*
- **SQ4:** *What methodological limitations characterize the use of CIS data in innovation research?*

The sub-questions are investigated in the four separate research papers comprising the second part of the dissertation. The first three of these deal with specific areas of innovative search, and the fourth reflects on some of the methodological challenges that arise when a Community Innovation Survey (CIS) is used as a basis for empirical analysis in the exploration of innovative activities, as it is in this dissertation.

1.3 Defining the concepts of behaviourally inspired innovative search

This chapter discusses the fundamental concepts of search-based innovation. Figure 1 presents the main mechanism of innovative search indicating that it is a complex activity, which involves different types of search activities: problemistic, slack-based, internal, external, local, and distant. They all are closely associated with innovation process of a firm. Here the term 'innovative search' is conceived as an 'umbrella concept' that covers the all above-mentioned innovation related search activities. The concept highlights the central role of knowledge and other resources as important elements of innovative search when generating new combinations (Schumpeter, 1934). In general, they can be divided into 'resources' and 'capabilities' (Amit & Schoemaker, 1993), where the resources are referred as tradable and non-

specific to the firm and the capabilities in turn are referred as firm-specific often non-tradable resources that are embedded in the processes of firms (Makadok, 2001). Importantly, the capabilities can also be seen as firms' capacity to deploy the tradable and non-specific resources.

The above distinction has been widely adopted in resource-based and other modern strategic management views used in this dissertation (Barney, Wright & Ketchen, 2001; Helfat et al., 2007). Meanwhile, the knowledge as a form of capability can be conceived as a "...cognitive capability that empowers its possessors with the capacity for intellectual or physical action" (David & Foray, 2003). Such knowledge is a central ingredient in the process of innovation. Essentially, it should be conceived different from 'information' (Cowan et al., 1997), which can be referred as taking "...the shape of structured and formatted data that remain passive and inert until used by those with the knowledge needed to interpret and process them" (David & Foray, 2003). It is also important element of innovation process. For example, von Hippel (1994) discussed the nature of 'sticky information' in innovation process, which refers to an information that is costly to acquire, transfer, and use in a new location.

When comparing them, the difference of knowledge and information can be seen when one looks at the reproduction of them. The replication of information basically corresponds to price of making copies. Meanwhile, the price of reproducing the knowledge, which mostly occurs through training and practice, is much more expensive due to the fact it requires cognitive capabilities that are difficult to articulate and transfer to others (David & Foray, 2003; Cowan et al., 1997). The difficulty of articulating and transferring is closely associated with tacit elements of knowledge; tacit knowledge. The fact that we know more than we can tell speaks to the tacit dimension. Instead, another fringe of knowledge is a codified or explicit

knowledge such as blueprints, formulas or computer codes. Considering above, the nature of knowledge can be perceived in a kind of a continuum where another fringe is tacit and another codified knowledge. However, there is a relationship between the codification of knowledge and the costs of its transfer; the more codified the knowledge is in nature, the more economical it is to transfer (e.g. Teece, 2000). That is a consequential aspect especially when searching new knowledge outside the firm in order to innovate.

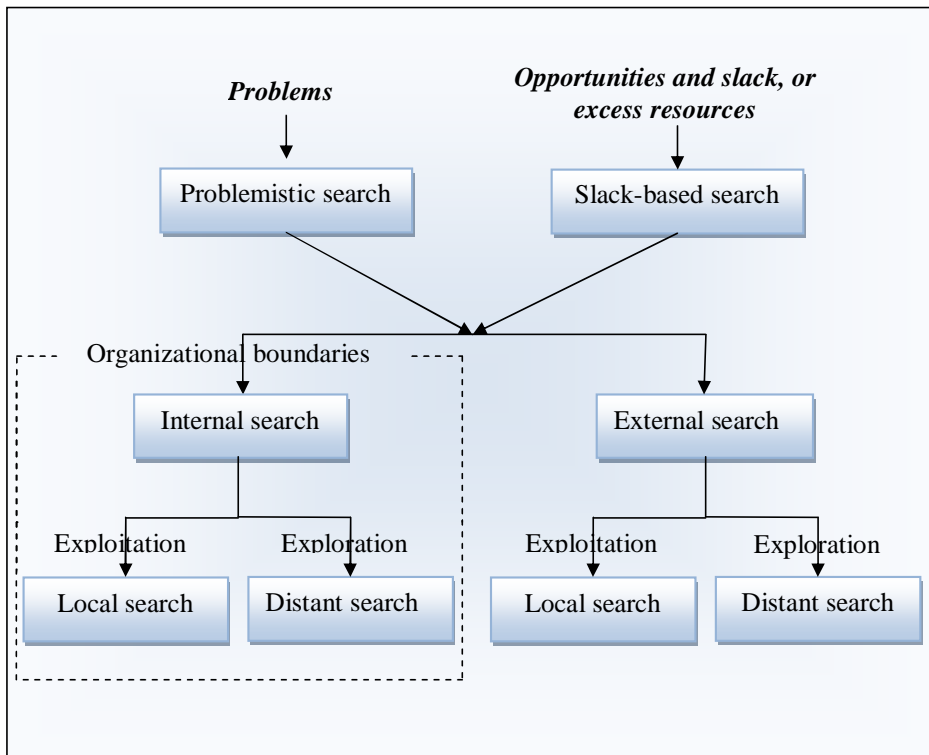


Figure 1. The main mechanism of behaviourally driven innovative search

The origins of search-based innovation lie generally in the behavioural theory of the firm. In the 1960s scholars from the Carnegie school identified two

fundamental, but at the same time also quite reverse mechanisms, to explain what factors induce search activities (Cyert & March, 1963; 1992). Figure 1 outlines the behaviourist proposal used in this study. The implication is that search is driven by (i) organizational problems or (ii) opportunities of organizational slack. Furthermore, the proposal indicates that search should not be seen as a random activity, but once induced firms intentionally – at least to some extent – manage it differently depending on existing needs, resources, routines and capabilities. Uncertainties about future outcomes and the choices made by other actors will also affect the direction. They will be carefully dealt with below. In general, the way in which firms manage their search can be conceptualized in terms of two different boundaries: (i) organizational (internal vs. external search) and (ii) technological (local vs. distant search) (Rosenkopf & Nerkar, 2001). The main aspects of these fundamental concepts of search are discussed below. However, it would seem logical to begin this examination of the search process from the inducement perspective. What triggers the search in the first place?

1.3.1 Problemistic vs. slack-based search

The behavioural theory provides some fundamental answers to the question above. Most importantly, it suggests that problems are among the main drivers of innovative search. That is, search should be seen, at least in part, as a problem-driven activity related to the expectations, aspirations and performance of firms, involving the satisficing behaviour of boundedly rational members of the organization. Generally, the behaviourists state that search “... is stimulated by a problem (usually a rather specific one) and is directed toward finding a solution to that problem” (Cyert & March, 1963, p. 121). This kind of search is labelled problemistic search. From this angle the problems – the difference between expectations (or the current situation)

and aspirations (Bromiley, 2005) – trigger the search activities, and innovation could thus be conceived of as a new solution to a current problem confronting the organization (Cyert & March, 1963, p. 278). Meanwhile, the bounded rationality of the members of the organization indicates that due to cognitive limitations, lack of resources, finite amount of time, and complexity of surrounding environments, the decision-makers are unable to act as rational humans that can optimize the all choices available (Simon, 1956), which characterize the search behaviour. Simon proposes that due the reasons above the decision-makers become ‘satisficers’ accepting satisfactory solutions, which are good enough for their purposes rather than finding the optimal solutions to the problems faced in organizations.

Apart from theoretical arguments, it has also been empirically shown that problems drive innovative search. Greve (2003, p. 696), for example, found that problems were central driver of organizational search through R&D – organizations often start launching innovations in order to improve low performance. The problem-driven search is also closely associated with the concept of technological paradigm, which in general refers to solutions to specific technological problems (Dosi, 1982) – radical innovations, for example. That is, an innovation process can in many ways be seen as a problem-solving process (Dosi, 1988). Interestingly, the behavioural mechanism behind problemistic search follows a systematic logic. If the actual performance or performance expectations⁴ fall below a satisfactory level of aspirations⁵, it starts a search for ways of reaching the aspiration level. If the firm fails to find solutions its managers are forced to lower their current levels of aspiration

⁴ Depending on the context, the firm might use calculated performance expectations (e.g., forecasts or budgets) or actual performance (Bromiley, 2005, p. 28).

⁵ The aspiration level reflects the target level of performance the firm pursues. It has two important aspects: dimension and level. The *dimension* represents the aspirations, e.g., innovations, patents, or profits, and for each of these there is a target *level* that defines when the dimension is satisfactory. The levels are determined mainly in accordance with the past performance of the focal form or of firms in the peer group (Bromiley, 2005, p. 26-27).

(Bromiley, 2005). The search intensifies when the organization performs below aspiration levels, and slows down when its performance exceeds them (Greve, 2003, p. 55)⁶. It should be noted that, largely on account of bounded rationality, the search becomes less intense when satisficing behaviour is achieved at the *minimal* level of aspiration in relation to performance expectations. It is also worth mentioning that the concept of satisficing is highly firm-specific, in other words different performance levels satisfy different firms in different ways.

There are three fundamental assumptions in the behavioural theory of the firm that determine the nature of problemistic search. The first is that it is motivated by *profit-seeking* behaviour (instead of profit maximizing behaviour). The implication is that a perceived problem triggers the search for new alternatives. The problem thus reflects the fact that the firm's performance does not meet expectations, or falls below a certain aspiration level. The search keeps going until the problems are resolved. This may happen in two ways: either the firm finds an alternative solution that satisfies the goal, or it revises its goals such that some solution in the 'universe' of alternatives becomes viable, i.e. satisfies the revised goal (Cyert & March, 1963, p. xx). The second assumption is that the search procedure is "*simple-minded*": in other words the search is in the hands of boundedly rational decision makers, who first tend to limit it to the neighbourhoods of the current alternatives. If the search fails to identify close alternatives, then the scope is broadened to more distant options.

In addition, problemistic search always remains simple-minded in the sense that firms tend to start it in the most obvious places, in the known or local environment. This is a natural outcome of the routine-based backward-looking behaviour assumed in the behavioural and evolutionary traditions. Finally, the search is also necessarily

⁶ In other words, the failure to meet aspiration levels generates the problem – the difference between expectations (or the current situation) and aspirations on a specific dimension. Thus the specific unattained aspiration level defines the problem (Bromiley, 2005, p. 29).

biased in the sense that even firms within the same industry view their environment differently, reflecting variations in their path-dependent experiences, learning and training, and the different goals of the coalition members. This makes them heterogeneous as a group. Accordingly, search behaviour is always more or less backward looking and based on existing routines and capabilities, which is indicative of path dependency. The further from existing routines and capabilities the decision makers dare to go in their search – thus reflecting a distant search – the higher are the risks of failure.

Somewhat paradoxically, the problemistic search hypothesis implies that firms in trouble are more innovative than successful firms. However, recent empirical studies have indicated that this does not fully hold true (see Pitelis, 2009). In industries operating in uncertain and turbulent environments such as ICT and biotechnology the most successful companies are often also the most innovative. This “behavioural anomaly” can be explained through another search mechanism that drives innovation; *organizational slack*. The slack can be traced back to excess resources (Penrose, 1959), which results opportunity-based search processes (Pitelis, 2009). The original behaviourist definition of slack refers to “...payments to members of the coalition in excess of what is required to maintain the organization” (Cyert & March, 1963, p. 36).

The behavioural theorists claim that slack has important role organizations stabilizing them two significant significant ways: “(i) by absorbing excess resources, it retards upward adjustment of aspirations during relatively good times; (ii) by providing a pool of emergency resources, it permits aspirations to be maintained (and achieved) during relatively bad times” (Cyert & March, 1992, p. 44). Later, Nohria & Gulati (1996, p. xxxx) defined slack as a “... pool of resources in an organization that

is in excess of the minimum necessary to produce a given level of organizational output”. This definition comes close to Penrose’s concept of excess resources as a source of economic growth and innovation (Penrose, 1959; Pitelis, 2007).

Thoughtfully, Volpe & Biferali (2008) summarize Penrose’s notion as follows (p. 120):

“She explicitly suggests that the interaction of human resources and between human and non-human resources spurs knowledge creation within firms through specialization and the division of labor, learning and teamwork. Specifically, it is the availability of unused resources within the firm which leads the firm to diversification or expansion of existing lines. Unused resources can vary, and they can originate sales, managerial, research or productive excess capacity. Excess resources result from increased productivity for the latter allows less time to be required in order to perform current activities. Therefore, they can be profitably used at zero marginal cost thus providing management with an incentive to innovate and expand. The process is simple. As people become accustomed to their jobs, formerly difficult task tend to become more or less routine so that management is free to assume new responsibilities. In such a situation, expansion may occur by absorbing the unused or partially used resources.”

In other words, firms can use their excess resources to expand activities in order to promote growth and innovativeness. In the same fashion, behavioural theorists propose that slack facilitates innovation, thereby providing funds for innovative activities that drive technological change (Cyert & March, 1963).

Given that “slack” may appear in different forms in different organizations, the concept is further split into three sub-categories (Bourgeois, 1981; Bourgeois & Singh, 1983; Singh, 1986). First, there is available or unabsorbed slack, which refers to available resources and capabilities that are not yet committed to particular allocations. To take a very simple example, there may be excess liquidity that is not needed to run day-to-day operations. Second, there is recoverable or absorbed slack, referring to resources already absorbed by the organization. For example, overhead costs are sometimes regarded as absorbed resources that can be recovered through

increased efficiency when needed elsewhere. Third, potential slack refers to the capacity to generate new resources: it may be the capacity to raise additional debt or equity capital, for example. These three categories have been found relevant in terms of shedding light on where the slack may lie within the organization. In sum, when it comes to technological change, slack could be considered a crucial facilitator of innovative behaviour in that it tends to create favourable conditions allowing firms to experiment and introduce new innovations.

The more slack resources there are, the more there are to devote to the search. This may take place either *internally*, or *externally* (e.g., by networking with external partners, imitating rival firms or absorbing generic science-based knowledge) (see Cohen & Levinthal, 1990 on the idea of absorptive capacity). Given that excess resources have often already been earmarked to provide services for a specified amount of time, managers are presumably motivated to apply them to new activities at almost no extra cost, thus engendering endogenous innovation and growth (Pitelis, 2007, p. 480). In other words, slack gives management the incentive to allocate excess resources to innovative and other expanding activities (Pitelis, 2004). This, together with the management goal to solve existing problems, could trigger innovative search based on the desire to take advantage of unused opportunities in order to improve the firm growth and performance.

There is some recent evidence of the relationship between slack and innovation, which indicates that it is not necessarily linear. Indeed, Nohria & Gulati (1996) discovered that these two activities have an inverted U-shaped relationship, which is indicative of diminishing returns. In other words, it is suggested that organizational slack tends to promote innovation up to a certain point, whereas excessive slack rather tends to hinder it. Nohria & Gulati (1996) also argue that too

little slack is harmful because it discourages any kind of risky experimentation, whereas too much is detrimental to innovativeness because it breeds satisfaction as well as a lack of discipline (p. xxx).

1.3.2 Internal vs. external search

Many firms face the challenge of effectively managing a multi-directional search process within the search space. The literature on innovation has historically conceptualized the direction of search in terms of organizational boundaries, in other words as *internal* and *external*. Specifically, the boundaries are used to determine whether the firm operations are owned or controlled by the firm. Given the initial inducement, the direction is most strongly affected by existing path-dependent knowledge, resources, routines and capabilities, which firms historically tended to develop internally in order to promote innovation. Internal search could be defined as the "...firm's search of its own, previously created knowledge" (Katila, 2002, p. 997) and other resources, which implies that the operations go on inside its organizational boundaries. This typically refers to internal R&D activities. Internal search activities generally require lots of employee time and effort. They also require firms to add to their existing technological knowledge, and to find novel ways of recombining existing knowledge and other resources.

It is clear that modern firms are increasingly engaging in external search activities in order to complement their internal search processes. Such activities involve the use of intra-industry and extra-industry sources of innovation such as competitors, customers, universities and suppliers (Chesbrough, 2003; Chesbrough, 2006; Klevorick et al., 1995; Cohen et al., 2002; Pavitt, 1984; von Hippel, 1988; von Hippel, 1987; von Hippel, 2005; Teece, 2007). Thus, external search could be defined as search activity that takes place outside organizational boundaries. Just like internal

search, it can also be driven by problems or slack-based opportunities. Given the increasing trend towards externally oriented search, it seems that there has been a shift from the traditional 'closed' innovation model to an 'open' model that involves the increasing use of external ideas, information and knowledge alongside internal sources (Chesbrough, 2003; 2007; 2011). Chesbrough argues that closed innovation model has mainly been eroded due to the increased mobility of skilled workers, external options for unused technologies, expansion of venture capital, and increased availability of capable outsourcing partners among other things.

The open-innovation view suggests that modern innovation processes relies on both internal *and* external knowledge. Firms expanding their search space to the external environment could also enjoy significant advantages in terms of innovativeness. However, successful external search usually requires significant investments in internal knowledge and other resources, in other words in absorptive capacity (Cohen & Levinthal, 1989; 1990). By absorptive capacity, Cohen & Levinthal (1990) refer to "...the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (p. 128). They further suggest that such ability it is largely a function of the firm's level of prior related knowledge, indicating that benefit from external search often requires prior internal search in related areas. Interestingly, although external search may be highly useful in promoting innovativeness, recent empirical research suggests that the benefits of openness or external search strategies may well be limited.

It could thus be concluded that the relationship between an open search strategy and innovative performance is not linear either. Indeed, Laursen & Salter (2006) found when they explored the effects of both the breadth and the depth of external search activities that active searching was curvilinearly (taking an inverted

U-shape) related to innovative performance. They suggest that the curvilinearity could result from over-searching, given that external search tends to be expensive, laborious and time-consuming. All in all, the above findings indicate that the benefits of openness or external search seem to be subject to diminishing returns. This dissertation will make similar conclusion in terms of relationship between openness and profitability (see empirical section). Nevertheless, the literature seems to be unequivocal in positing a strong correlation between external search and innovation.

1.3.3 Local vs. distant search

The literature on innovation, organization and strategic management traditionally distinguishes between two different dimensions of technological search: *local* (also called exploitation), i.e. based on existing routines and capabilities, and *distant* (also called exploration), i.e. based on new routines and capabilities (Nelson & Winter, 1982, March, 1991; Rosenkopf & Nerkar, 2001; Katila & Ahuja, 2002; Benner & Tushman, 2007). These two dimensions reflect the technological boundaries of available technological solutions in the search space; including the technological familiarity of the solutions found. Whereas “local” in this context refers to close, related and familiar technological solutions based mainly on internal learning, “distant” refers to more remote solutions that are not technologically familiar. The implication is that the probability of finding successful solutions declines linearly as the technological distance from the current technologies increases (Verspagen, 2005, p. 500) and firms have to learn new routines and capabilities, which is costly, time-consuming and full of risks.

Most search activities tend to be local in nature, in other words they focus on familiar path-dependent technologies as well as existing routines and capabilities. The tendency to prefer local search derives from the uncertainties as well as the cognitive

limits – bounded rationality – of the people working within the firms (Cyert & March, 1963). History matters, and firms could be considered path-dependent (David, 1975), meaning that new choices are influenced by the choices that have been made in the past. Given that path dependency is closely involved in the process of technological change, previous searches constitute the natural starting point for new searches (Nelson & Winter, 1982; Kogut & Zander, 1992; Stuart & Podolny, 1996; Rosenkopf & Almeida, 2001). Consequently, local search tends to generate incremental technological change because of the limitations of earlier search activities.

Path-dependent local search based on the exploitation of existing routines and capabilities is standard behaviour in firms. It has many advantages in the innovation process, not least because it tends to decrease the uncertainties involved. Otherwise it may sometimes be counterproductive, especially in the long run if firms undertake it excessively at the expense of more risky but potentially higher-return-generating distant search activities. From this perspective, local technological boundaries may also limit the possibilities of firms to find genuinely more useful technological solutions (Fleming & Sorenson, 2004). Because the local environment cannot always provide a satisficing solution to existing problems, they have to rely on distant problemistic search activities as well (Cyert & March, 1963).

In line with the above reasoning and previous empirical evidence, it thus seems that problemistic search sometimes encourages firms to develop “core rigidities”, in other words to rely too much and for too long on local exploitative search, or to fall into “competency traps” (Rosenkopf & Nerkar, 2001), in other words overreliance on local learning that has been but is no longer successful (see Leonard & Barton, 1995; Levitt & March, 1988; Levinthal & March, 1993). Firms may therefore be forced to broaden their search scope to encompass more distant

technological domains that cross local technological boundaries. Although this kind of search increases innovation potential through the re-combining of resources, routines and knowledge (Teece, 2007), at the same time it increases the costs of the search and the related risks. Furthermore, distant search processes are more likely than local strategies to shift the nature of technological change in a more radical direction based on exploration.

Whereas local search is associated with the refinement and extension of existing technological knowledge, distant search often involves experimentation with novel technological alternatives (March, 1991; Rosenkopf & Nerkar, 2001), which have greater potential to create a basis for radical new combinations and breakthrough innovations. Interestingly, in practice local and distant search (or exploitation and exploration) are not mutually exclusive, nor are they substitutes: successful learning and innovating processes in fact require both of them at the same time (March, 1991). Given that both search activities use the same scarce resources, firms must be able to find a balance between them. As Levinthal & March (1993, p. 105) state, the "...basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, to devote enough energy to exploration to ensure its future viability. Survival requires a balance, and the precise mix of exploitation and exploration that is optimal is hard to specify". This is one of the major challenges involved in managing technological innovation.

2 Theoretical background

The aim in this chapter is to expand on the above-mentioned behavioural aspects of search and thus offer a broader understanding of the search-based innovation process; how it helps firms to achieve sustainable competitive advantage. Innovative search is thus placed into a larger dynamic framework within which firms

undertake search activities in order to enhance their competitiveness by means of technological innovation and new combinations (Schumpeter, 1934; Teece et. al., 1997; Pierce & Teece, 2005; Teece, 2007). The framework combines elements of well-established theories and views, including the evolutionary theory of economic change (Nelson & Winter, 1982), a behavioural theory of the firm (Cyert & March, 1963), the resource-based view of the firm (Wernerfelt, 1984; Barney, 1991), the knowledge-based view (Kogut & Zander, 1992; Grant, 1996) and the dynamic capability view (Teece et al, 1997; 2007), literature on sources of innovation and open innovation (von Hippel, 1988; Chesbrough, 2003; 2007; 2011), as well as some other innovation literature (Dosi, 1982; 1988; Pavitt, 1984). In combination, this will help in placing innovative search in a context in which it can be seen as a central driver of sustainable competitive advantage.

2.1 Evolutionary economics and innovative search behaviour

Evolutionary economics is loosely based on a model of biological evolution according to which organisms evolve in response to their changing environment (Pierce et al., 2002). In an economics context, the evolutionary theorists view the entrepreneurial activities as a process of competition and the markets as a selection mechanism that winnows the good and bad products and processes. The framework helps to explain the evolution of firm populations in constantly changing business environments. Meanwhile, it views the behaviour of individual firms through organizational routines. Indeed, most firm-level tasks such as manufacturing, new product development and marketing are carried out in routinized ways (Becker, 2008). In this sense one could say that firms operate in accordance with different organizational routines that are used as the main unit of analysis in evolutionary economics. Nelson & Winter (1982) originally defined routines as “regular and

predictable patterns of firms” (p. 14). Evolutionary reasoning further implies that the routines are executed through individuals employed by the organization.

Routines have many important functions in the organizations (see Ståhle et al., 2002), p. 54 –55). Among them, (i) they consist of skills, competences, habits, and experiences of individuals employed by the organization. The routines thus form a basis for the emergence of more collective capabilities. (ii) Routines also manifest the way how boundedly rational decision-makers in the organization act in complex and uncertain situations. That is, they are prone to rely on previously used routines that have worked well in the past. In this sense, the routines constitute a regular and stable basis for the operations of the business organizations. (iii) Routines also generate path-dependencies, meaning that the behaviour of organizations is constrained by their existing routines. (iv) Finally, the routines also serve as organizational memories where cumulative learning based tacit knowledge can be embedded in. This helps to protect the firm internal pieces of knowledge as well.

According to the evolutionary view, firms that generally have better routines tend to prosper and grow relative to those whose routines are less well suited to the existing competitive environment (Nelson, 1987, p. 21). Thus, routines rather than individuals or any other actors are the essential components in explaining firms’ population dynamics from evolutionary perspective. If nothing in the environment changes, the routines of individual firms will not change either. In such a situation the ecosystem is in a stationary circular flow (Schumpeter, 1934), meaning that the firms keep on operating as usual. In reality, however, population environments change and evolve over time as a result of new technologies introduced in the markets, or regulation and/or changes in consumer preferences, for example. If a firm does not

respond to the change by renewing itself there comes a point when its prevalent routines become inadequate to compete with rival firms.

From the evolutionary perspective, this unsatisfactory situation triggers the process of searching for more competitive, innovative ways of doing things, in other words to find new routines in order to keep up with the competition. As implied above, in behavioural terms this refers to problem-driven search activities aimed at achieving a performance level that complies with the aspiration level. The satisficing aspiration level cannot be achieved unless the outcomes of the search activities – i.e. new combinations (Schumpeter, 1934) – pass the selection mechanism of market competition (Nelson & Winter, 1982). The search for new routines may encompass various dimensions within the technological or organizational boundaries. This is the main domain of this study, which explores how firms search internally and externally across organizational boundaries. Evolutionary economics draws on the Schumpeterian heritage, which highlights the role of innovation as a critical dimension of market competition functioning as a crucial selection mechanism (Schumpeter, 1934; 1942; Nelson & Winter, 1982).

As early as 1911, Schumpeter noted that innovation was a critical dimension of economic change, which in turn revolved around innovation, entrepreneurial activities and market power. Technological innovation often created temporary monopolies, thus allowing abnormal profits that would later be competed away by rival firms and imitators. Schumpeter suggested that these temporary monopolies were necessary in order to provide incentives for firms to develop new products and processes, which he originally defined as ‘new combinations’ of new or existing knowledge, resources and equipment, for example (Schumpeter 1934, p. 65). Building on this, evolutionary theorists saw the new combinations as central drivers of

economic change, even if incentives to invest in innovative activities were seen somewhat differently. They also assumed that profits exceeding the industrial average are mostly generated through successful new innovations (Dosi & Nelson, 1994).

According to evolutionary economics, three fundamental mechanisms, *variation*, *retention* and *selection*, explain the evolution of the corporate population under market competition (Nelson & Winter, 1982, Nelson, 1987). Variation, which in the context of economics is intentional rather than blind, results mainly from Schumpeterian new combinations – or innovations - created mainly via slack- and problem-driven search activities undertaken by alert entrepreneurs (Kirzner, 1997). Variation appears either in the form of completely new combinations or through diversification and specialization within existing combinations. When new combinations are introduced, some existing ones simultaneously disappear from the markets (Saviotti, 1991). This “creative destruction” is where the selection mechanism, which reflects the crucial role of market competition, comes into the picture. Consumer and buyer market demand indirectly selects from a variety of ideas (created by alert rival entrepreneurs) the fittest new combinations that will be fully developed into new products, services, technologies, firms, and even ecosystems. Hence, consumer preferences play a crucial role in the evolutionary view of market competition.

Not all new combinations pass the selection test, however. This is where the third mechanism, termed retention, comes into play in that it gives firms “...time to develop new routines and capabilities and to stabilize the behavior when coping with radical uncertainty” (Kyläheiko, 1998, p. 330) in the changing business environment. Retention derives from organizational routines and capabilities (or bundles of routines) (Barney, 2001, p. 646), thus partly reflecting the development of best practices

(Ventresca & Kaghan, 2008, p. 70). Routines stabilize firm behaviour given that forming new ones takes significant amounts of time. Without the mechanism of retention the pressure of selection could well lead to too violent changes with fatal consequences if effective selection mechanisms were to destroy new ideas before they were developed to become successful practices and routines (Kyläheiko, 1998, p. 330). All in all, evolutionary economics thus provides a theoretical framework within which to explain the dynamic behaviour of corporate populations (e.g., firms in the same industries or ecosystems). However, another approach is needed to explain a single firm's internal behaviour within the population.

2.2 Behavioural theory as a background for innovative search

Whereas evolutionary economics opened up the dynamics among populations of multiple firms, the behavioural theory of the firm shed light on the dynamics of an individual firm within such a population (Cyert & March, 1963). Given the emphasis in this study on firm-level innovative activities, behavioural theory provides some useful concepts that enhance understanding of the fundamental behaviour of business firms. At the same time, it also gives some insights into innovative search. According to the theory, the internal behaviour (e.g., decision-making) of firms can best be understood in terms of variables that affect three separate although interlinked behavioural concepts: (i) *organizational goals*, (ii) *organizational expectations* and (iii) *organizational choice*. In terms of *organizational goals*, the theory criticizes the traditional conception in neoclassical economics of exclusive reliance on profit maximization as an ultimate goal of an organization. It assumes that organizations cannot have goals, but there are many goals that are formed in interaction between various participants (with different preferences) involved in the organization.

In other words, in behavioural terms firms are seen not as solitary units with one common goal (e.g., profit maximization), but rather as coalitions of participants or stakeholders that can be further organized into sub-coalitions (e.g., R&D staff, board of directors, shareholders) with their own conflicting agendas and goals. The multiple goals of different stakeholders cover a wide variety of functions within the firms, including sales, purchasing and new product development, for example (Pierce et al., 2002). Given these multiple goals, there is significant potential for internal conflict among members promoting their own goals. Cyert & March (1963) call such a situation without internal goal consistency an *intrafirm unresolved conflict*. According to behavioural theorists, these conflicts are resolved through bargaining processes, which include political compromises among coalition members, and also so-called ‘side payments’ in return for some agreement (Cyert & March, 1963, p. 31).

Goal inconsistency is one reason why stakeholders compete for limited resources in pursuing their own goals (research and development managers, for example, may need to bargain over resources in order to meet goals set for innovative performance). The goals reflect the demands of a political coalition of multiple participants, and change as the composition of the coalition changes (new stakeholders enter the organization or old stakeholders leave, for example) (Dew et al. 2008). Goals are closely linked with aspiration levels, which in fact could be seen as a function of: (i) the organization’s past goals, (ii) its past performance, and/or (iii) the past performance of other comparable organizations (Cyert & March, 1963, p. 115) – in other words its competitors. Aspiration levels are thus used as benchmarks for satisfactory aspirations. In this sense the organizational goals are closely related to the firm’s internal behaviour in terms of the “performance – aspirations – search”

framework presented earlier: if performance is not on a satisfactory level in relation to the aspiration level, the search for solutions to improve it is initiated.

Organizational expectations reflect the way in which firms search for information from the environment in order to form their performance expectations. Behavioural theory does not assume that firms are able to gather all the relevant information and perfectly calculate the expected outcomes in terms of performance, however (Pierce et al., 2002). At the same time, it conceives of firms as highly heterogeneous entities with firm-specific standard operating procedures – or operational routines. The heterogeneity is attributable partly to bounded rationality, and partly to path-dependent routines. The idea is that because of the bounded rationality of the participants involved in the organization, firms tend to constitute their performance expectations based on available information drawn through search activities from their neighbourhoods. Given that the information is obtained through boundedly rational search, there is no such thing as perfect information/knowledge in the behavioural context (Cyert & March, 1963, p. 9-10). Firms cannot, therefore, optimize their behaviour. Hence, the theory emphasizes satisficing and profit-seeking behaviour (Winter, 1964). Implicit in the concept of “profit seeking” is that decision makers do not optimize “...over latent choice set, but rather stop searching when they identify an alternative that satisfies their various performance criteria” (Gavetti et al., 1997 p. 527, based on Simon, 1955; 1956).

The third key concept, *organizational choice*, reflects the response to a specific problem (e.g., decision-making over alternative ways of resolving problems) (Cyert & March, 1963). Accordingly, the behavioural view of the firm can be operationalized through backward-looking standard operating procedures (cf. operational routines in evolutionary economics). It also assumes that prior experience

is embodied in standard operating procedures, thus reflecting solutions to former problems and negotiated resolutions of past conflicts. When the experience changes, the firm's path-dependent routines and standard operating procedures also gradually change as a result of organizational search, learning, and negotiation or bargaining processes (Augier & March, 2008, p. 3).

Standard operating procedures can be further divided into: (i) specific standard operating procedures and (ii) general choice procedures. The former are highly firm-specific, and also static in the sense that they enable firms to replicate previously "satisficingly" performed tasks. General choice procedures, in turn, are related to decision-making. They allow firms to choose from among different alternatives identified in order to address specific problems (Nokia, for example, had to make a choice between the Android and Windows operating system, having conducted an external search for solutions when struggling to develop its own functional system). According to behavioural theory, general choice procedures tend to follow the following three basic principles:

(i) *Avoid uncertainty*. The implication is that firms look for procedures enabling them to make decisions that minimize the need for predicting an uncertain future. One could assume that the principle only holds for choices that entail about the same expected amount of risk (e.g., if a firm has two competing investment options that have the same expected risk premium, it will probably choose the one with fewer predicted uncertainties). Firms avoid uncertainty by making contracts, planning activities in advance, obeying the rules among other things. (ii) *Maintain the rules*. Once a firm has determined a set of decision rules it will abandon them only if necessary. This results in stable and predictable behaviour. (iii) *Use simple rules*. Firms making choices also rely on individual judgment in order to introduce some

flexibility into simple general rules (Cyert & March, 1963; 1992; Mahoney, 2004). In other words, the rules need to be simple enough so that each individual can successfully apply them in different situations. Importantly, all the above principles derive from searching the environment and solving internal problems (Pierce et al., 2002).

2.3 From behavioural and evolutionary theories to modern strategic management

Both of these evolutionary and behavioural theories have significantly affected the current literature on strategic management, which emphasizes the role of innovation as a major source of competitive advantage (Helfat et al., 2007). Most importantly, the behavioural theory of the firm showed scholars of strategic management that firms are heterogeneous entities that consist of path-dependent but also relatively constant standard operating procedures (Pierce et al., 2002; Teece & Pierce, 2005). In the face of some early contradictory views (e.g., Porter, 1980), the notion of heterogeneous firms has been widely adopted in the modern literature (Wernerfelt, 1984; Teece et al., 1997). However, although taking account of the heterogeneity of firms, the theory missed some other essential aspects of strategic management in that it did not focus on competitive advantage.

In particular, behavioural theory did not pay much attention to firms' long-term strategic options, in other words how they cope with dynamic business environments in order to create and sustain competitive advantage. Two decades later, evolutionary economics brought in the "missing" component of strategic intent to the analysis of business firms (Hamel & Prahalad, 1989), as well as some additional dynamics. According to the evolutionary approach, firms no longer exclusively follow their existing standard operating procedures or routines, but are perceived as entities

that have some ability to affect their long-term survival and competitiveness. From the strategic-management perspective, the implication is that firms can actively change over time by means of search routines that help them to promote innovation (cf. behavioural theory, according to which a firm changes in response to specific problems). In other words, in evolutionary terms firms are capable of intentionally changing their routines, resources and capabilities in a dynamic environment in order to position them in a strategically favourable manner. Without such strategic intent they could just be seen as “puppets” of their own characteristics with no hope of sustainable competitive advantage (Pierce et al., 2002).

In light of the above discussion on the behavioural and evolutionary theories, it could be said that the modern strategic-management view encompasses a larger dynamic framework of firm activities including concepts such as resources, innovation, knowledge, routines, search and capabilities, all of which help to explain dynamic behaviour in changing environments in which firms compete in the area of technological change. Figure 2, which comprises a model adapted from Kylaheiko et al. (2002), summarizes these concepts and their relationships. It helps to integrate innovative search, the principal research subject of this study, into a wider theoretical context in which the behaviour of firms is mostly characterized by failure, opportunities, technological change and competition (Penrose, 1959; Cyert & March, 1963; Nelson & Winter, 1982; Wernerfelt, 1984; Teece et al., 1997). In combination, the above concepts provide a fruitful basis on which to examine firm-level innovative activities from the strategic-management perspective.

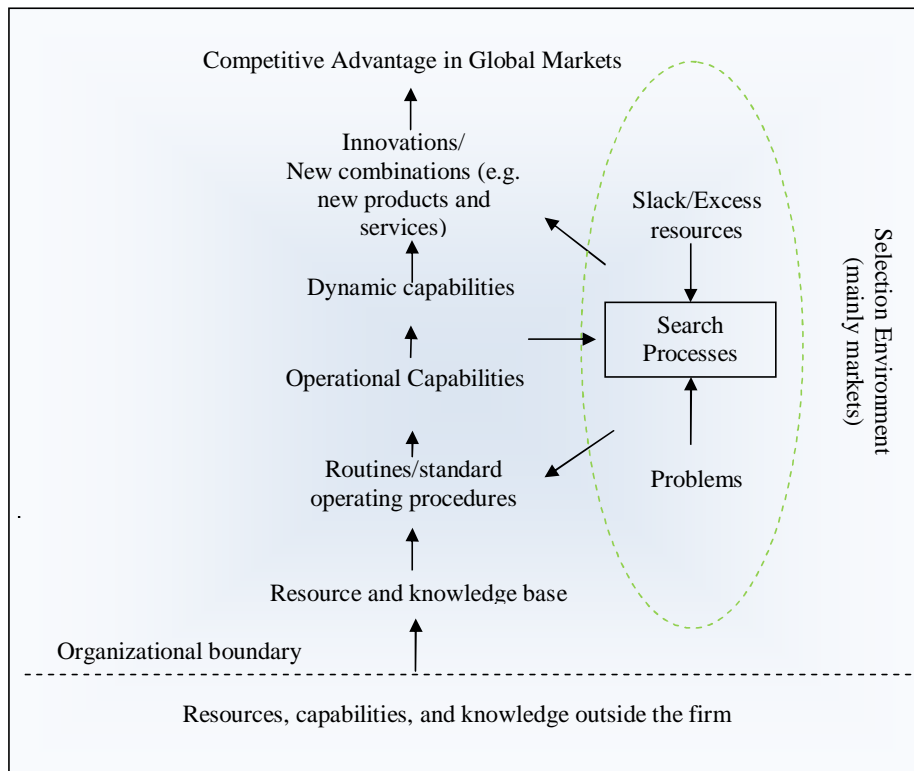


Figure 2. A search-based evolutionary framework of firm competitiveness (adapted from Kylaheiko et al., 2002)

The aim in the following paragraphs is to illustrate how innovative search can promote sustainable competitive advantage (e.g., the ability to generate above-industry-average profits in the long run) in a strategic-management context. It is advisable to start from the resource-based view of the firm (RBV), which in many ways could be considered the basis of modern strategic-management thinking if the Porterian five forces model following the industrial organization tradition is left aside. In terms of competitive advantage, the RBV posits that sustainable competitive advantage requires a bundle of valuable resources that are heterogeneous, but not

perfectly mobile across firms (Wernerfelt, 1984; Peteraf, 1993, p. 180). In other words, it is assumed that firms differ from each other in terms of their resource bases. Furthermore, competitive advantage requires resources with certain qualities.

According to Barney (1991; 2001), only firm-specific resources that meet the so-called *VRIN attributes* (valuable, rare, imperfectly imitable and non-substitutable) can serve as sources of sustainable competitive advantage. Such resources are most often firm-specific that are difficult to imitate, transfer and trade (among other things because there rarely are well-developed market for them) and their value tends to be context dependent (Katkalo et al., 2010). They can be tangible, but they are more likely intangible. Katkalo et al. (2010) mention intellectual property, know-how, customer relationships and knowledge possessed by groups of skilled employees as examples of resources that satisfy the VRIN attributes. In general, the RBV further posits that without the VRIN attributes a firm could only generate industry-average profits, or might even stay below this level. Within this framework, the resources of firms are employed through firm-specific routines or bundles of routines, which can generally be called capabilities (Amit & Schoemaker, 1993; Cockburn & Henderson, 1994; Prahalad & Hamel, 1990; Winter, 2003; Zollo & Winter, 2002; Peng et al., 2008). Hence, the RBV highlights the role of internal factors in explaining sources of competitive advantage.

In this sense, the RBV differs substantially from Porterian microeconomics-based strategic management theory, which suggests that sustainable competitive advantage can be achieved by responding to external opportunities and threats, or to changes in competitive forces such as barriers to entry, buyer power, supplier power, the threat of substitutes and the degree of rivalry (Porter 1979; Porter, 1980). Empirical evidence (e.g., Rumelt, 1991) indicates that external, industry-level factors

do affect competitive advantage to some degree, but internal factors matter much more. Somewhat on the basis of this empirical evidence, it is assumed in this study that internally oriented models such as the RBV comprise a more fruitful starting point from which to examine the empirically relevant sources of sustainable competitive advantage. The main weakness of the RBV is that in many ways it is static, and in some cases perhaps even tautological, explaining “success by success” (Priem & Butler, 2001).

The RBV has been extended in order to avoid the pitfalls of staticness and tautology. One major advance was the development of the knowledge-based view of the firm (KBV) (Kogut & Zander, 1992; Grant, 1996), according to which knowledge is strategically its most significant resource. This is based on the fact that firm-specific knowledge-based resources tend to be the most difficult for rival firms to imitate and transfer because of the imperfections inherent in knowledge markets. This holds true especially in the case of tacit knowledge, which is more or less collective in nature and is often embedded in organizational routines and capabilities, resulting from path-dependent learning and search processes. In this sense, organizational routines could also be seen as repositories of knowledge (Nelson & Winter, 1982). That is, knowledge can be seen to be embedded in routines and business processes of firms. Alongside the KBV, which moves in a dynamic direction in that it focuses on the role of learning and knowledge, the dynamic capability view (DCV), which attempts to address some main shortcomings of the static RBV, was another major step forward (Teece et al., 1997; Teece, 2007).

The DCV is becoming the prevalent theoretical view in the literature on strategic management (e.g., Helfat et al., 2007; Barreto, 2010), not least because it pays significant attention to the crucial role of innovation. Dynamic capabilities were

originally defined as “the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece et al. 1997, p. 517), which includes the idea of competing and adapting to changes in the environment through innovation (Teece & Pisano, 1994). Competences (resulted from activities that are performed repetitively)⁷ (Katkaló et al., 2010, p. 1177) are comparable to resources that are traditionally viewed as being employed through operational capabilities that help firms to operate in a static way, in other words to organize the retention function that is fundamental to the evolutionary view. Operational capabilities consist of a bundle of operational routines (Amit & Schoemaker, 1993; Cockburn & Henderson, 1994; Prahalad & Hamel, 1990; Winter, 2003; Zollo & Winter, 2002; Peng et al., 2008), which Nelson & Winter (1982) and Pierce et al. (2002) refer to as *static* routines that allow the firm to replicate previously performed tasks.

When firms need to change their ways of doing things they need dynamic capabilities, which help them to renew themselves by orchestrating their resources so as to be able to compete when the change is rapid (Teece, 2007). In this way, dynamic capabilities reflect “the capacity of an organization to purposefully create, extend, or modify its resource base” (Helfat et al., 2007, p. 4). According to this recent definition, firms need dynamic capabilities in order to renew their resource base, which would otherwise remain unchanged even if the environment changed, and this would put selection pressure on them. Dynamic capabilities are also based somewhat on bundles of search routines (Zollo & Winter, 2002), which are dynamic and on which firms rely when seeking new product and process innovations. The search routines are heavily embedded in research and development activities (Pierce et al., 2002). This

⁷ Katkaló et al. (2010) further states that competences “...enable economic tasks to be performed that require collective effort” (p. 1177).

connection makes DCV highly relevant from the perspective of this study. Unlike static routines, dynamic routines (and the capabilities based on them) enable firms to change along with their environment.

The concept of dynamic capabilities, or bundles of dynamic routines, has recently been disaggregated into the firm's capacity to: (i) sense weak signals, (ii) seize market opportunities and (iii) reconfigure its resource base accordingly (Teece, 2007, p. 1319). This disaggregation helps to open up the role of innovation when it comes to the exploitation of dynamic capabilities. From the DCV perspective, the *sensing* of new opportunities refers to the firm's ability to seek new ideas, information and knowledge from different sources (e.g., internally or externally), whereas *seizing* indicates that once the opportunity has been sensed (e.g., based on slack-driven search), it must be addressed through new products and services, processes and business models requiring investments in innovative activities. Finally, *reconfiguration* reflects the allocation, reallocation, combination and recombination of existing and new resources in a novel manner in order to generate new combinations or innovations (Teece, 2007). Through this channel innovative search could be conceived of as a specific type of dynamic capability that helps firms to find new ways of combining both existing resources and new resources in response to the change.

The literature on strategic management identifies many other dynamic capabilities as well as search, such as new product development (which comes close to innovative search), strategic decision-making, and the ability to cooperate (Eisenhardt & Martin, 2000). This study focuses only on one specific dynamic capability, innovative search, which is highly effective in terms of orchestrating the resource base. Specifically, it could be seen as a process in which firms innovate

through searching, transferring and combining knowledge and other resources from a variety of different internal and external sources in a novel manner in order to compete in global markets. The implication is that the path-dependent firm-specific resources resulting in a form of heterogeneity among the firms can largely be traced back to problem-and-opportunity-driven search activities.

There is recent empirical evidence of the importance of search activities interpreted as dynamic capabilities. For example, Ahuja & Katila (2004) show that resource heterogeneity among firms tends to emerge as a response to search activities aimed at resolving the idiosyncratic situations they face. The authors claim that such solutions can finally be transformed into performance-enhancing capabilities. In this sense these search activities really are dynamic capabilities. Ahuja & Katila focus on two different types of idiosyncratic situations, problems and opportunities that firms tend to face in their local innovation searches, which comes close to the inducement mechanism of innovative search introduced earlier (Pitelis, 2007). They found that the variety of problems and opportunities could also lead to variety in the firms' resource bases when they followed different search paths in response to challenges (p. 903). This is at the heart of the notion that dynamic capabilities help firms to reconfigure their resource bases in order to better compete in global markets.

3 Methodology

3.1 Background for data gathering and measurement of innovation

This dissertation follows a vast number of previous studies using a large-scale quantitative data to empirically address research questions on innovation (Schmookler, 1966, Mansfield, 1983; 1986, Pavitt, 1984, Levin et al., 1987). There have historically been many alternative ways to measure and gather the data on

technological change (e.g. Freeman & Soete, 2009). Considering above, Archibugi & Pianta (1996) classified the most common approaches into two main groups (see also OECD, 1997; 2005; Smith, 2004): (i) *Patent data* (patents, patent applications, and patent citations), and (ii) *Innovation surveys* (object- and subject- based approach). Following the recent studies on innovative search, this dissertation relied on the subject-based innovation survey (Laursen & Salter, 2004; 2006; Fontana et al., 2006). This chapter discusses the approaches above and introduces dataset as well as main econometric methods used in the dissertation.

3.1.1 Patent data

Patent data has historically been one of the main sources of information to explore technological change (Jaffe, 1986; Schmookler, 1966; Griliches, 1990); including the behavior of innovative search (e.g. Stuart & Podolny, 1996; Katila, 2002; Nerkar, 2003; Ahuja & Katila, 2004; Fleming & Sorenson, 2004). Patent data can be divided into: (i) patents, (ii) patent applications, and (iii) patent citations. Generally, a patent refers to a “...document, issued by an authorized governmental agency, granting the right to exclude anyone else from the production or use of a specific new device, apparatus, or process for a stated number of years” (Griliches, 1990, p. xxx). Since the patenting requires novelty from the objects, the patents as such provide a useful indicator of innovative activities. Meanwhile, the patent citations made by patent office examiners refer to a previous work important to an invention, which is relevant to the current patent application. The citations have been specifically used when investigating knowledge flows and spillovers between the patents and patenting firms (e.g. Jaffe et al., 1993; Henderson et al., 1998; Almeida, 1996). Overall the patent system gathers a great deal of detailed information about

firms' innovative activities into a public record that can be further used to explore technological change (Smith, 2004).

When using patent data for measuring innovative activities, the individual patents (or applications or citations) become a unit of analysis (Archibugi & Pianta, 1996). To make useful firm-level analyses, the patent data therefore often needs to be complemented by other data as well. The advantage of patent data is that it has been gathered for a very long time. Therefore it provides long time-series that are well suitable for measuring impacts of dynamic and long-lasting innovation processes. Patents are also internationally comparable, which enables comparative cross country analyses on innovation. However, patent data has some disadvantages as well. For example, not all innovations are patented, propensity to innovate changes from industry to industry, the patents as such tell little about how the innovation process is organized, patents vary in economic importance across different sectors, many patents do not eventually lead to commercially successful products and services, and in some cases they may rather reflect firms' appropriability strategies than innovations. Since this dissertation focuses on examining questions about the use of internal and external sources of knowledge, the patent data as such did not provide suitable ways to address the set research questions.

3.1.2 Innovation surveys

3.1.2.1 Object-based approach

Innovation surveys can be divided into object- and subject- based approach (Archibugi & Pianta, 1996). The object approach is a survey based method for measuring innovative activities. Specifically, the object approach refers to a survey of innovation *counts* drawn either from expert interviews or bibliometric data sources.

Such count is a direct measure of innovation representing the unit of analysis in object approach (Archibugi & Pianta, 1996). The object-based data therefore usually needs some additional data sources to enable useful analyses on firms' innovative behavior. SPRU database of University of Sussex is probably the most well-known object based innovation database covering a total about 4.300 innovations from the years 1945 to 1983. The database was collected using a panel of about 400 technical experts across different industries (Smith, 2004). It has been successfully used in a number of innovation studies (e.g. Pavitt, Townsend & Robson, 1987; Pavitt, Robson & Townsend, 1989; Tether et al., 1997). In addition to expert interviews, the bibliometric method provides another useful object based approach to measure and gather information on innovation.

Perhaps the best known bibliometric method is the "Literature-Based-Innovation-Output" (LBIO) method (e.g. Coombs et al., 1996). In LBIO method, the innovations are counted from the selected group of technical and trade journals as well as other bibliometric sources. The method has been successfully used in various innovation studies (see for example Kleinknecht & Bain (eds) 1993). Some object-based databases have also been built based on the joint use of the above methods (see for example SFINNO database). While object approach provides a direct measure of innovation, there are some disadvantages related to it as well. For example, the value of innovation counts may vary a lot, the counts alone do not provide any firm-level information about the innovation process, not all innovations are introduced in the journals, the object based data may easily become biased and non-representative, the data on innovation counts contains information exclusively about the innovating firms. Since the counts as such reflect innovation outputs before anything, the object approach was not considered suitable for addressing the research questions of this

dissertation, considering that it mainly focused on analysing questions concerning the sources of innovation. Hence the subject-based approach provided a more suitable option.

3.1.2.2 Subject-based approach

The subject-based approach is an alternative survey based method for the object-based approach. The approach is generally based on a designed survey questionnaire mailed to a representative population of firms that enquires information from the respondents (e.g. a representative of a firm) about the area of interest such as innovative activities. In the subject approach, a firm is the unit of analysis (Archibugi & Pianta, 1996). The survey questionnaire helps to acquire detailed information about the firms' innovation processes as a whole (e.g. obstacles to innovation, sources of innovation, cooperation partners in innovation process), not just the innovative outputs. YALE Survey was one of the first large-scale subject-based innovation surveys (Levin et al., 1987). Since the implementation of YALE a great deal of other innovation surveys has been implemented as well. One of them is a Community Innovation Survey (CIS), which has so far become the most influential subject based firm-level innovation survey to study technological change.

Since it was launched in the beginning of 1990s, it has resulted more than 200 research papers on innovation (e.g. Tether, 2002; Brouwer & Kleinknecht, 1999; Belderbos et al., 2004; Veugelers & Cassiman, 2005; Cassiman & Veugelers, 2002). Following them, this dissertation relied on the CIS data as well. Hence, the CIS system will be introduced in detail in the following chapter. When looking at the characteristics of the subject-based approach, it has some important advantages compared to the approaches mentioned above. For example, it offers a possibility to gather information on innovation with wide coverage of issues needed, the sample of

firms can be made statistically representative, and the data can be acquired from the original sources of information. Especially, the fact that it enables to gather information about the innovation process as a whole including specific ways of organizing it internally, advocated for the subject approach. On the other hand, the obvious disadvantage of it is, however, that the information received from the respondents is based on subjective views, potentially on rough estimates, of individuals about the object asked. Furthermore, the representativeness of the results is closely tied to response rate achieved (Kleinknecht et al. 2002).

3.1.3 Community Innovation Survey (CIS)

This dissertation relies on Community Innovation Survey (CIS). The CIS is a postal survey conducted four-yearly in European Union (EU) Member States to collect firm-level community innovation statistics. It is coordinated by Eurostat and implemented by Central Statistical Offices of the EU Member States. By 2012 a total of 6 CISs have been conducted in the Member States (CIS 1, CIS 2, CIS 3, CIS 4, CIS 2006, and CIS 2008). It therefore provides an opportunity for the use of secondary data for the research purposes. The CIS is based on Oslo Manuals 1992, 1997, and 2005 and some earlier subject based surveys such as the YALE survey as well (OECD, 1992; OECD, 1997; OECD, 2005). Over the years the CIS has been constantly improved along the updated manuals that have served as important technical guides to develop measurement and implementation of subject-based innovation surveys. The first edition of the Manual, issued in 1992, and the surveys such as CIS using it, demonstrated the potential of subject-based large-scale innovation surveys to gather data on the complex and differentiated process of innovation across national borders. Prior to CIS, national statistical offices had mostly been focused on collecting R&D statistics, which have the well-known disadvantages in measurement of innovation

(e.g. Kleinknecht et al., 2002). Five years later in 1997, the second edition of the manual was issued. It updated the framework of concepts, definitions and methodology to better incorporate survey experience and greater understanding of the innovation process and to cover a wider range of industries (OECD, 2005).

The 1997 update of Manual improved the guidelines for developing internationally comparable innovation indicators for OECD countries and discussed some analytical and policy problems relevant for the indicators (OECD, 2005). The latest version of the manual was introduced in 2005. It drew on the large amount of data and experience resulting from the prior surveys. It expanded the innovation measurement framework placing a greater emphasis on the role of linkages between firms and different institutions in the innovation process, thus recognizing the importance of innovation in less R&D-intensive industries as well, and expanding the definition of innovation to include two additional types of innovations, organisational and marketing innovation (OECD, 2005). From the research perspective, CIS produces a broad set of indicators on innovation activities, innovation spending, effects of innovation, public funding, innovation co-operation, sources of innovation, hampering factors of innovative activity and methods of protecting intellectual property rights that can be used to analyse innovative behaviour of firms. The data collected through CIS is highly protected. The direct access to the anonymised data is only provided by means of research contracts in Central Statistical Offices of each Member State or Eurostat. The access is basically restricted to universities, research institutes, national statistical institutes, central banks inside the EU and EEA countries, as well as to the European Central Bank.

While CIS represents the subject-based innovation survey approach at measuring innovation, it has many advantages as a survey on innovation: (i) it is

based on a solid methodology – Oslo Manuals (OECD1992; 1997; 2005) – developed by OECD and other experts, (ii) it is well piloted, tested, and constantly further developed by statistics authorities and other experts, (iii) the CIS data are collected by national Statistic Centres that are specialized in data collation, which helps to achieve high response rates to form representative samples, and to combine the data with other databases occupied by Statistics Centres, (iv) the CIS is well-established; a large number of peer reviewed academic research papers have been published based on CIS data. As Laursen & Salter (2004; 2006) summarize, CIS provides an alternative way to examine the innovative search considering that most empirical studies on search have previously been based on patent statistics (e.g. Fleming, 2001; Katila, 2002; Nerkar, 2003; Ahuja & Katila, 2004; Fleming & Sorenson, 2004). However, the CIS also has its shortcomings such as cross-sectional nature of the data and vagueness related to some questions as a basis of individual innovation indicator. Therefore one of the empirical studies attached in this dissertation is focused on the problems related to the CIS-based data when doing innovation research.

3.2 Dataset used in this study

Dataset used in this dissertation was built in two stages based on four different sources of data: (i) Finnish Innovation Survey 1998 – 2000 (Yritysten innovaatiotoiminta 1998–2000 -kysely), (ii) Finnish Innovation Survey 2000 – 2002 (Yritysten innovaatiotoiminta 2000–2002 -kysely), (iii) Business register data, and (iv) Tax Office data. Finnish Innovation Survey is the national label for Community Innovation Survey. The 1998–2000 survey was implemented in 2001 by Statistics Finland. It forms the basis of the dataset in a sense that other data is gathered for the population of that survey. The dataset was acquired from Statistics Finland mostly in 2004, but it was later expanded by means of some financial data from Finnish Tax

Administration. Due to the reasons of security, the data was physically located at the Research Laboratory of Statistics Finland where all the analyses of the dissertation have been executed.

The Finnish Innovation Survey 1998–2000 was part of the EU wide CIS presented above. In Finland, the questionnaires were posted to 3.462 firms across the manufacturing and service industries. Only firms that had at least 10 employees were included in the survey. The response rate of the survey was high 50.1 per cent (1.661 responding firms). In this dissertation the focus is on a subsample of innovating firms since there was only limited information on non-innovating firms; and no data was imputed on the missing values of non-innovating firms. No imputation has been done in prior studies either (e.g. Mohnen et al., 2007). The CIS data was complemented by data gathered from the Business Register, which is a Register of Enterprises and Establishments and a Register of Public Corporations maintained by Statistics Finland. The Business Register provides information from the service database formed of the Register of Enterprises and Establishments. It covers all enterprises, corporations and self-employed persons that are liable to pay value added tax or have paid employees. The Business Register data include enterprises' addresses, branches of industry, size categories of personnel and turnover, dates of establishments and importer/exporter data. The data sources of the Business Register are several administrative records and Statistics Finland's direct inquiries to enterprises.

The 2000–2002 survey was only a partial CIS implemented together with yearly R&D survey in 2003, including information exclusively on innovative outputs. The first part of the questionnaire is equal to official full the CIS. It was therefore only used as a complementing data for innovative outputs, enabling the analysis of lags between independent and dependent variables in one of the empirical analyses

done. Finally, the 1998–2000 survey sample was complemented with the financial data collected by the Finnish Tax Administration. The data, which were drawn for the years 1998 to 2004, are official data used for tax assessments. They are annually gathered via income statements and balance sheets based on the standardized Accountancy Decree and following the guidelines of the Finnish Accounting Standards Board. The value of merged financial and innovation survey data has been established in previous studies (Leiponen, 2000; 2005). The tax data was used in later stage to form measures of profitability that were the concern in one of the empirical studies, when the relationship between openness and profitability was analysed.

3.3 Econometric methods used

This chapter will shortly discuss the econometric methods used in the dissertation. The methods applied are closely related to the specific research questions appearing in the empirical studies attached in the dissertation. Of course, the methods used in the study are highly dependent on the dataset and dependent variables available. All the empirical analyses are based on different variations of the regression analysis: (i) *ordered logit regression*, (ii) *multivariate probit regression*, and (iii) *Arrelano – Bond estimator*, (iv) *linear regression*, and (v) *Tobit regression*. The dissertation thus follows a large number of prior innovation studies that have used the regression analyses when investigating firms' innovative activities (for example, Cohen & Levinthal, 1989; 1990; Cassiman & Veugelers, 2002). In general, the regression analysis enables to demonstrate above all how a value of the dependent variable changes when any one of the independent variables varies, while the other independent variables are held fixed.

The ordered logit regression uses, also called as proportional odds model, is a suitable regression technique when dependent variable has a sequential ordered

character having several categories (e.g. measured on a Likert-scale). In this dissertation, the technique was used in a model where the dependent variable was based on the importance of different sources of innovation measured on the four-point scale. The model only applies to data that meet the proportional odds assumption, that the relationship between any two pairs of outcome groups is statistically the same. This indicates that the coefficients that describe the relationship between, say, the lowest versus all higher categories of the response variable are the same as those that describe the relationship between the next lowest category and all higher categories, and so on. Since the relationship between all pairs of groups is the same, there is only one set of coefficients.

Multivariate probit regression method enables a simultaneous estimation of various probit regression equations. It allows the error terms of the regression equations to be freely correlated (Galia & Legros 2004). The method has become a common approach in the literature on technological change and it has been used, especially, in recent CIS-based studies (Belderbos et al. 2004; Galia & Legros, 2004). Commonly, the probit method does not assume a linear relationship between the dependent and independent variables, but are used to predict dichotomous outcomes that are mutually exclusive. That is, the dependent variables can only take two values, which are generally coded as "0" and "1" (e.g. a firm that uses universities are used as a source of innovation receives a value "1", a firm that does not use universities as a source of innovation receives a value "0"). Following some prior studies (e.g. Galia & Legros, 2004), the multivariate probit was used to analyse complementarities in this dissertation. The estimation statistics of the model include a covariance matrix that can be used for measuring complementarities between the dependent variables of the equations (significant positive correlations in the matrix reflecting the

complementarities and significant negative substitutes) (Arora & Gambardella 1990; Galia & Legros, 2004).

The dissertation also applies the *Arellano–Bond (A–B) dynamic panel–data estimator* (Arellano & Bond, 1991), which has become an established estimation technique in the economics literature for panel models predicting corporate profits (Geroski & Machin, 1993; Geroski, Machin & van Reenen, 1993; Leiponen, 2000). That is because the past profits tend to be highly correlated with the future profits. The A–B estimator is an instrumental variable method that allows a use of such lagged dependent variable and variables that are not strictly exogenous, but in fact either endogenous or predetermined. Since such variables do not meet the characteristics of strict exogeneity being uncorrelated with past, present and future values of the variables (e.g., future values of predetermined variables are correlated with previous error terms), the model requires instrumental variables to deal with the endogeneity bias that they cause in the model.

The advantage of the A–B estimator is that it does not require any additional instruments to deal with the issue of endogeneity given that it applies the first differenced regression equation in the estimation — removing the fixed effects bias — the lagged levels of the predetermined and endogenous variables remain available to serve as instruments in the model. Alongside the estimation the A–B estimator implements a Sargan test of over-identifying restrictions, which is used to indicate the validity of the instruments. To further validate them, it implements a test for second-order autocorrelation, which fundamental test as A–B models hypothesize that such autocorrelation does not exist in first-differenced errors terms. The second-order autocorrelation would be damaging for the validity of the instruments as its existence

would indicate that some lags of the dependent variable were endogenous and thus unsuitable to serve as instruments (Arellano & Bond, 1991).

Finally, this dissertation also applies *linear regression* and *Tobit regression* methods in one of its empirical papers. The linear regression minimizes the sum of squared vertical distances between the observed responses in the dataset and the responses predicted by the linear approximation. It is consistent when the independent variables are exogenous and there is no perfect multicollinearity or outliers in the dataset. The Tobit method in turn is a viable technique when dealing with the censoring of the dependent variable. When such variable is censored, values in a certain range are all transformed to (or reported as) a single value i.e. the dependent variable is zero for a significant fraction of the observations. The method is needed since conventional regression methods fail to account for the qualitative difference between limit (zero) observations and nonlimit (continuous) observations. In this dissertation, a left-censored Tobit was used for estimating innovative performance in terms of the percentage of new product sales.

4 The main results of the empirical papers

This chapter briefly introduces the empirical papers that together constitute the second part of the study. The papers address the research sub-questions posed in Chapter 1.2 dealing with innovative search and some methodological issues related to research based on the Community Innovation Survey. On the theoretical level they reflect the framework presented above, especially the behavioural and evolutionary concepts of how innovative search gets started and how modern firms manage the process across a variety of different sources of innovation. The content of the publications is summarized in Table 2, which sets out the research objectives, the theoretical perspectives, the methodological approaches and the main findings of each

one. Three of the four papers have been published in scientific journals, and the first version of the fourth paper was presented at the DRUID Summer Conference in 2007.

1. I'll find it where I can: Exploring the Relationship between Search and Problems among Finnish Innovators

As mentioned, this study uses the behavioural theory of the firm to explain why firms undertake innovative search activities. Although the theory clearly suggests that the search is often triggered by problems (Cyert & March, 1963), few attempts have been made to explore the influence of the nature and types of problems that firms face in their search behaviour. Innovating firms may be hampered by various problems related to finance, technology, asymmetric and incomplete market information, or a lack of qualified personnel, for example. It has been pointed out that such factors may have direct effects on innovative performance (Mohnen & Röller, 2005). However, little is known about how the nature of an innovation-related problem really affects the direction of search across organizational boundaries inside and outside the firm.

The study is based on a large dataset of Finnish innovators, the aim being to contribute to the literature on behaviourally-oriented innovative search in showing how various problems – in this case related to resources and finance – shape the direction of search in terms of four different knowledge sources (own enterprise, universities, suppliers and customers). A fuller understanding of their search behaviour will guide firms in directing their search activities in order to compete more effectively in global markets. In terms of the theory, it is suggested that models of behavioural search should take more account of the nature of search problems.

	Publication 1	Publication 2	Publication 3	Publication 4
Title	I'll find it where I can: Exploring the Relationship between Search and Problems among Finnish Innovators	Exploring the relationships between knowledge sources in the innovation process: evidence from Finnish innovators	Profiting from Openness: Exploring the relationship between profits and openness among innovating firms	Analysing innovative output in a CIS database: taking account of some nasty details
Objective	To examine the relationship between resource and finance problems and knowledge sources including universities, own enterprise, suppliers and customers	To examine the complementarities between different knowledge sources, including universities, own enterprise, suppliers and customers	To examine the relationship between openness to external knowledge sources of innovation and financial performance s	To reflect on some of the CIS-data related problems that have received relatively little attention in prior studies
Theoretical perspective	Innovative/Problemistic search, A behavioural theory of the firm, Open innovation, Absorptive capacity	Innovative search, Open innovation, Absorptive capacity, Complementarities	Innovative search, Open innovation, Absorptive capacity, Nelson's 1961 model	Methodological study applying traditional models of the determinants of innovation
Methodology	Quantitative, Ordered logit regression,	Quantitative, Multivariate probit regression	Quantitative, Generalized method of moments (GMM)	Quantitative, OLS regression and Tobit regression
Main findings	Resource-constrained firms tend to use external rather than internal sources of knowledge in their search activities. However, firms constrained by finance tend to search both internally <i>and</i> externally	The innovation process involves diverse and complementary interactions among various internal and external actors, but not all sources are complementary in nature	There is an inverse U-shaped relationship between firms' financial returns and the degree of openness in terms of the number of external sources of innovation they use	A number of methodological shortcomings related to CIS data that have not been fully addressed before are identified, including the need to consider typical life-cycle length and the neglect of lag structures.

Table 1. A summary of the research papers

2. *Exploring the relationships between knowledge sources in the innovation process: evidence from Finnish innovators*

As mentioned, recent studies on strategic management suggest that innovation is a central driver of sustainable competitive advantage (Teece et al., 1997; Martin & Eisenhardt, 2002; Teece, 2007; Pitelis & Teece, 2009). At the same time, according to the current literature, in order to promote innovation firms search for new knowledge from a myriad of different sources across organizational boundaries, including suppliers, manufacturers, customers, universities and competitors (Chesbrough, 2003; 2006; 2011; Pavitt 1984; von Hippel 1988; 2005; Tether, 2002; Laursen & Salter, 2006). Such externally oriented search activities are indicative of the fact that the innovation process involves diverse relationships between different types of knowledge sources, which is in line with the knowledge-based view of the firm (Kogut & Zander, 1992).

Thus far only little attention has been paid to those relationships, however. This constitutes a clear gap in that firms often struggle to find useful knowledge from a wide range of sources. The aim of this paper is to contribute to the current literature on innovative search, given that a deeper understanding of the relationships between different knowledge sources should help firms to better master the risks and costs they face in the distributed innovation process. The concept of complementarities (Galbraith & Legros, 2004) and a large dataset of Finnish innovators are used to explore the sources from which firms are most likely to find knowledge that is combinable. From the management perspective the results should help firms to avoid wasted search efforts. Theoretically, the study gives some preliminary indications of what sources of knowledge are complementary.

3. Profiting from Openness: Exploring the relationship between profits and openness among innovating firms

The current literature on strategic management also suggests that firms adapt to change and compete mostly through technological innovation (Teece et al., 1997; 2007). Innovative activities are managed quite differently, depending on the nature of knowledge and other resources. There is increasing evidence that firms are moving away from relying on internal R&D as the central mechanism in the search for innovation, and shifting to more open and distributed models (Chesbrough, 2003; von Hippel, 2005). Such activities are promoting a new range of related practices in which external partners are engaged in firm-level innovation efforts, thus making the firm's search processes more externally and collaboratively oriented. Nevertheless, little is known about how such efforts really shape the firm's performance.

Some recent studies in the area of strategic management have shown that an externally oriented search strategy, in other words openness to external sources of knowledge, is associated with innovativeness (Laursen & Salter, 2006). However, there is still a lack of convincing evidence that openness helps firms capture greater financial returns. This unresolved question is explored empirically in this paper, which applies Nelson's (1961) model as a basic theoretical framework. It is predicted that there is an optimal number of external sources, and hence that there exists an inverse U-shaped relationship between firms' financial returns and the degree of openness in terms of the number of external sources of innovation they exploit. This empirical study also relies on Finnish Community Innovation Survey data.

4. Analysing innovative output in a CIS database: taking account of some nasty details

The Community Innovation Survey (CIS) has become a main source of data for

European research on innovation. It is used in a variety of studies on technological change including this dissertation, which thus complements the recent literature on innovative search that has built on CIS data (Laursen & Salter, 2004; 2006). The use of innovation-related survey data is significant in this context in that most empirical studies thus far are based on patent data (Fleming & Sorenson, 2004, Ahuja & Katila, 2004; Katila, 2002, Nerkar, 2003; Nerkar, 2003). It is clear that the new survey data may open up some new avenues for innovative search as well. However, like it was expressed in the methodology chapter, the survey CIS also suffers from some methodological shortcomings. This study addresses some of them using Finnish CIS data (1998–2000 and 2000–2002). Indeed, they are used to illustrate some consequences of these potential shortcomings, and some ways of dealing with them are proposed. These types of methodological exercises are extremely useful for improving the quality of research on innovative search and technological change in general.

5 Discussion and contributions

Discussion

The aim of this study was to position innovative search in a larger dynamic-strategic-management framework in an attempt to explain the importance of technological change. The analyses were conducted mainly from the perspective of competitive advantage. The study built on some well-established theories, including the behavioural theory of the firm, the evolutionary theory of economic change, modern views on strategic management, and diverse literature on innovation. Given this theoretical basis, the innovation process is conceptualized, at least partly, as one of innovative search that is induced either by problems or by slack-based opportunities. Innovative search is further conceived of as one specific type of

dynamic capability among others (see e.g., Eisenhardt & Martin, 2000 for a similar consideration) that helps firms to adapt to constant change in the evolving business environment and to compete against their rivals.

Given the importance of technological change, a further aim of this study was to enhance current understanding in some specific areas of how the process of innovation should be managed in order to best promote firm-level innovative activities, and eventually also sustainable competitive advantage. It seems that the way in which firms tend to organize their innovative activities has been undergoing major changes in recent years. The dissertation builds on prevalent views that firms rarely innovate alone anymore, and tend to use multiple internal and external sources of knowledge and other resources to promote their efforts (von Hippel, 1988; 2005; Chesbrough, 2003). The *main research question* (MRQ) (see p. 9) of this study was based on the above reasoning, the aim being to add to the current understanding of how modern firms manage their search through multiple sources of knowledge. Four research gaps in the area of the MRQ were further identified, giving rise to an equal number of *research sub-questions* (SQs) (see also p. 9) dealing with specific questions related to the use of internal and external sources of innovation, as well as some methodological issues. The contributions of the study arise mainly from the empirical research papers that address the individual SQs, and are summarized below.

1st Contribution

The first contribution of this dissertation comes from Publication 1 and relates to the search behaviour of individual business firms. The paper largely relies conceptually on the behavioural theory of the firm, and especially on problemistic search, which is used to explain the inducement mechanism of innovative search. It seems that the problems faced by firms are fundamental drivers of innovative search,

and come in a number of different forms in the innovation process (e.g., a lack of qualified personnel, or finance). In spite of the heterogeneity among the problems however, the theory mostly deals with them as a homogeneous group on the assumption that they are all fairly similar. The theory says little about how the type or nature of the problem may affect the direction of the search activities, in other words across organizational boundaries. One might suppose that firms behave differently depending on the problems they face. This was considered a critical research gap that is further addressed in this study.

The first empirical paper contributes to the current literature in showing that the nature of problems – in this case financial and resource-related problems – tends to shape the search direction, at least in terms of organizational boundaries. It gives some preliminary results on how this comes about, the conclusion being that firms could best overcome finance-related problems by searching either internally using their own resources, or externally relying on the knowledge of sources such as universities or customers. The best response to resource-related problems, on the other hand, would be to search *only* externally, and not waste resources on internal search (for details see Publication 1). Although the above conclusions refer to SQ1, they also provide a basis on which to further develop the behaviourally inspired literature on innovative search from the perspective of the nature of the problem. This aspect should clearly be included in the relevant behavioural models.

2nd Contribution

The second contribution of the dissertation arises from Publication 2. It reflects recent views suggesting that firms increasingly search for, transfer and combine knowledge as well as other useful resources from multiple internal and external sources in order to promote their innovativeness (von Hippel, 1988; 2005,

Chesbrough, 2003; 2006; 2011; Cohen & Levinthal, 1989; 1990; Klevorick et al., 1995). Little is known about the diverse relationships among the multiple sources that characterize the modern innovation process. This was considered a critical research gap that deserved further attention. Given the lack of previous work in this field, the fundamental assumption was made that not all knowledge in the search space of different sources is equally combinable. In other words, it was assumed that some sources form a better match than others in terms of the type of knowledge they hold.

In the absence of an existing theory, these relationships were investigated via the theoretical concept of complementarities (complementarities demonstrate an increased likelihood of substitutes, and non-complementarities that such sources encompass combinable knowledge) in the spirit of some earlier studies (Arora & Gambardella, 1990; Galia & Legros, 2004). The analysis confirmed previous assumptions that the process of technological change is complex, involving diverse interactions with various internal and external sources. Nevertheless, some of the sources – universities in particular – are less able to incorporate combinable knowledge into knowledge from other sources. Through the concept of complementarities the dissertation concludes that the direction of search matters as far as recombining knowledge from different sources is concerned. That is to say, random targets of search may put firms in situations in which they face the great challenge of finding combinable knowledge. These preliminary statements should encourage scholars to pay more attention to relationships between different knowledge sources.

3rd Contribution

The third contribution arises from Publication 3, which deals with the concept of open innovation and thus focuses on externally oriented innovative-search activities. It is acknowledged that firms have become increasingly open about their

innovation processes (Chesbrough, 2003; 2006). Moreover, there is a lot of empirical evidence showing that firms today build their innovative activities on external sources of knowledge such as universities, customers, suppliers and competitors (e.g., von Hippel, 1988). Nevertheless, the recent evidence indicates that there are some limits to the benefits of openness. Although there are clearly some advantages, it has been shown that excessive openness can be harmful to innovative performance (Laursen & Salter, 2006). Meanwhile, there is little information about how openness to external sources of knowledge shapes financial performance, and therefore the profitability of business firms.

It is thus unclear whether or not it pays off financially to search externally and to be open about innovation. This study contributes to the current literature exploring the relationship between openness and financial rewards. Evidence obtained from a rich dataset of Finnish innovators suggests that there are some limits to the financial benefits of openness: indeed, the relationship (taking an inverted U-shape) between the two was found to be curvilinear. The implication is that there are costs involved in the open innovation process in terms of additional risks of knowledge leakage and investments made in searching for, transferring and combining knowledge from external sources. Therefore, whereas managers may benefit from openness, they should be wary of being too open about innovation (for detailed arguments see Publication 3).

4th Contribution

The fourth contribution of the dissertation stems from Publication 4, and is twofold. On the purely methodological level, the paper examines some challenges related to research on the firm-level determinants of innovation based on the Community Innovation Survey (CIS). It identifies some previously unrecognized

methodological shortcomings inherent in CIS studies. These include common method bias and the neglect or lack of structures in regression models, and differences in the length of life cycles related to indicators of innovation output, together with other issues that are generally not addressed in studies on the determinants of innovation (for details, see Publication 4). Additionally, the paper combines two rounds of Finnish Innovation Surveys in order to construct proper lag structures for the models explaining firm-level innovative performance. There are still very few studies that use more than one innovation survey (for exceptions, see Belderbos et al., 2004; Belderbos et al., 2004).

The second contribution relates to the comparison of lagged vs. non-lagged regression models on the determinants of innovation (for the years 1998-2000 and 2000-2002), which facilitates assessment of the reliability of cross-sectional CIS. To date, no other such exercise has been executed. The models include some fundamental control variables, but also some interesting independent variables covering different types of cooperation partners (e.g., suppliers, customers, competitors and universities). The analyses indicate that the lagging of the variables has some consequences on the results, for example in terms of the effects of R&D intensity (for details see Publication 4). Interestingly, in all the models there is only weak evidence for the claim that cooperation would really promote innovative performance among innovating firms. Given that it is against the mainstream conception of external cooperation, it should encourage scholars to keep on exploring issues related to cooperative innovation.

6 Limitations and future research

This chapter summarizes the limitations of the dissertation, and identifies some opportunities for future research. Each publication additionally includes detailed

discussion on the paper-specific limitations and opportunities. First, innovative search is conceptualized in the dissertation as a specific type of dynamic capability. The trouble is that ever since the concept was introduced, researchers have been asking questions about what dynamic capabilities really are (Eisenhardt & Martin, 2000). Moreover, the original definition put forward by Teece et al., 1997 (see also Teece & Pisano, 1994) has been further developed (e.g., Helfat et al., 2007; Teece, 2007). Hence, there is currently no clear-cut definition of dynamic capabilities, and this naturally blurs the empirical research focus (see e.g., Arend & Bromiley, 2009). Arend & Bromiley also criticize the DCV for its lack of coherent theoretical foundation, claiming that it is based on a “casual mixing” of concepts from different theories (e.g., competences, routines, standard operating procedures, assets, resources, capabilities, and so on), which causes inconsistencies among papers explaining the same view (p. 81).

Second, there are still very few empirical studies on dynamic capabilities, which in many respect results from the above-mentioned difficulties when operationalising them, mostly because of their firm-specific and tacit nature. For example, it is hard to operationalise new product development as a single capability given that it is a highly multidimensional process involving different resources, routines and capabilities. Thus far, moreover, most studies on dynamic capabilities are based on case studies and cross-sectional data, which is problematic given that the research subject is highly dynamic in nature (Arend & Bromiley, 2009). Future research should therefore aim to further develop some robust empirical ways in which to: (i) first identify and (ii) then, based on longitudinal time-series data, empirically test how dynamic capabilities tend to function in practice. In other words, the theoretical hypotheses would require more empirical support than is currently available.

Third, the DCV concept clearly implies that there are many different types of dynamic capabilities (e.g., Eisenhardt & Martin, 2000). This dissertation focuses on one specific type – innovative search. Future research should further extend the empirical work to other types of dynamic capabilities (e.g., identify them), and also construct models that incorporate various capabilities at the same time in order to better understand their mutual relationships. Fourth, and finally with regard to the DCV, some scholars have called for clearer managerial guidance on the choices firms have in dealing with dynamic market competition. For example, managers often need guidance in choosing where to seek the knowledge and other resources they need to overcome particular problems faced in the innovation process. Although this study takes some modest steps in this direction, such as in drawing conclusions about where firms can best find solutions to problems in their innovation processes, future research should continue in its efforts to provide straight managerial implications.

The fifth point is related to the behavioural inducement mechanism of innovative search. As important as problems are as an inducement mechanism, future empirical research should not be limited in this respect, and should focus on other mechanisms as well. Indeed, given that empirical investigation of problemistic search in the innovation context is in its infancy (for an exception, see Greve, 2003), future efforts should pay much more attention to organizational slack and excess resources as inducement mechanisms of innovative search (for an earlier exception, see Nohria & Gulati, 1996). Future studies should investigate, for example, how different types and forms of organizational slack (e.g., potential slack compared to absorbed slack) shape innovative search behaviour.

Sixth, the concept of open innovation is used to theorize external search behaviour across organizational boundaries (Chesbrough, 2003). At the same time,

the relevant discussion on appropriability regimes is purposefully not incorporated into the study (Teece, 1986). In reality, appropriability goes hand in hand with the question of openness. Namely, whereas the creation of innovations tends to require openness, their successful commercialization may well require appropriability (Laursen & Salter, 2005). Thus, openness and appropriability are closely intertwined. Future studies should include appropriability conditions in research on innovative search (a tight regime might limit the options for external search, for example). Additionally, in the context of open innovation, attempts should be made to distinguish between product and process innovations: the latter are often rooted in the firm's core competences, which are harder to replace with external knowledge.

Seventh, alongside the literature on openness, the study also relies on the narrow concept of knowledge sources (taken from von Hippel, 1988). The trouble is that it does not give a full picture of the multidimensional nature of knowledge or information: it is known, for example, that knowledge may take a number of different forms (i.e. tacit, codified) (Cowan et al., 1997) and information can sometimes be sticky (von Hippel, 1994). Importantly, the nature of the knowledge may affect the way in which firms search, transfer and combine it. Given the data limitations, it was not possible in this study to consider the nature of knowledge in more detail in the empirical models. Future research should take this into account in studies exploring the search behaviour of firms.

Eighth, other dimensions of search should also be investigated. This study was limited to technological and organizational boundaries, and empirically to search across the latter. There are clearly other levels and dimensions of search activities that should be investigated further in order to enhance current understanding of how firms really seek new knowledge. For example, given the on-going globalization of

business, future research could take a geographical perspective across cities, municipalities, countries and continents.

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